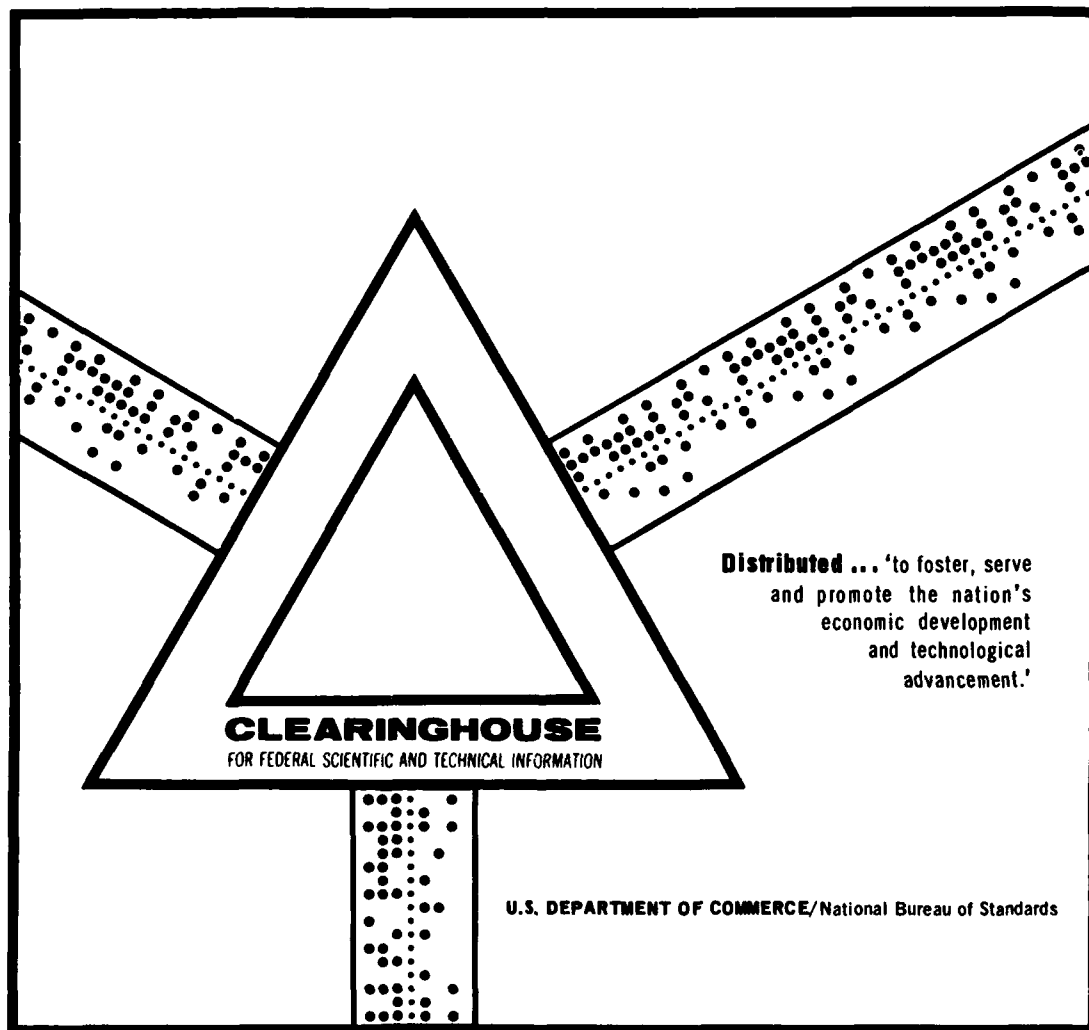# THE IMPLICATIONS OF ADP NETWORKING STANDARDS FOR OPERATIONS RESEARCH

Paul L. Peck

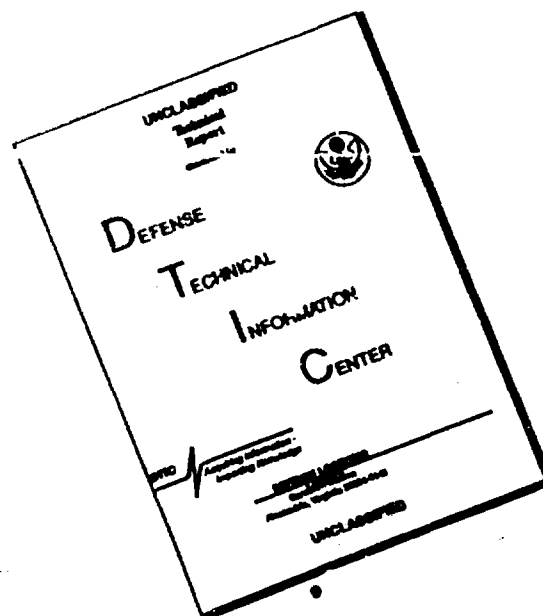Mitre Corporation
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THE IMPLICATIONS OF
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FOR
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INTRODUCTION

The demand for larger, more comprehensive operations research (OR) computer programs has accelerated with the development of faster, more versatile computing systems. Similarly, the demand for computer support in other areas such as accounting, personnel, and statistics has also increased. If the need for ADP support continues to grow at the present rate, the majority of ADP users may find themselves constrained by the available computer support at their installation.

Workload sharing was proposed as a possible means of improving ADP support to customers, but initial attempts were frustrated by the plethora of incompatible systems, terminology differences, and the variety of documentation techniques in use.

Acting upon customer complaints of the poor quality and high cost of ADP support, the Bureau of the Budget recommended that standardization efforts be initiated and that the General Services Administration manage the utilization of all government computers. The result has been a determined effort to develop, implement and enforce the utilization of standard procedure-oriented languages, data elements, and documentation techniques. At the same time, the General Services Administration (GSA) was promoting compatibility in its effort to increase the utilization of the data processing facilities available to the government. GSA has continued to promote the utilization of workload sharing techniques to alleviate the overloading of certain facilities by transferring some of the extra work to under-utilized data processing centers rather than increasing the size of overloaded facilities.

If this trend continues, the result could be the develop ent of a workload sharing network concept which would tie togeth r a number of independent computer facilities, in order to improve

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overall ADP support and/or reduce turn-around time. Successful networking requires that additional standards and conventions be developed so that jobs can become facility-independent and data can be stored in a format and form useful to a number of users with common objectives.

This general tendency toward networking, together with the recent Congressional investigation into the high cost of Department of Defense (DoD) studies, will affect most Operations Research (OR) project leaders in the near future. Both the DoD and the Department of the Army (DA) have stressed the need for the integration of all study efforts and urged that comprehensive standards be developed which will preclude duplication of effort, reduce the time required to perform such studies and provide for more usable results.

Faced with the ADP coordination attempts of GSA, and the OR integration efforts of DoD and DA, operations research project leaders should take the initiative in addressing the following issues:

- the common needs of the operations research community,
- the types of standards that would facilitate the network processing of OR programs, and
- the factors which would encourage the use of these standards.

PRESENT SITUATION

The growth of operations research (i.e., the application of mathematical and statistical methods to the study and analysis of complex inter-disciplinary problems) was spurred by the development of bigger, faster computers. As these computers were developed, more complex OR problems with a larger number of variables and additional constraints could be investigated. In addition, as computing power increased and computing costs decreased, it became economically feasible for the operations research analyst to examine many problems which had been neglected in the past. Hence, today,

we find the Army performing OR studies in many areas (e.g., logistics, R&D, material systems analysis, and management). As a result, although computing capability has increased significantly, computer users have been more than equal to the task of utilizing this additional capability, leading to facility overloading and turn-around time problems (the amount of turn-around time is measured from the time of job submission to the time of receipt of the job output).

Since the progress of operations research projects appears particularly dependent on good turn-around time, and since there is such a great demand for ADP support, the OR project leader should seek to alleviate his dependence on a particular computer facility by developing machine-independent programs and data formats which can be handled by other computer installations.

The factors which have hindered the development of an integrated Army operations research capability and the growth of workload sharing between data processing facilities which serve OR customers are:

- the lack of a central agency to serve as a focal point for OR projects,
- short-term, individualized, assembly-language solutions to problems often resulting from incomplete literature searches,
- the lack of a library of operations research programs,
- the lack of a library of standard approaches to specific classes of OR problems,
- the lack of adequate benchmarks for the comparison of the many approaches to solutions of the various classes of OR problems,
- the problems of enforcing the utilization of a standard documentation technique,

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- the difficulty in developing standard data banks,
- the problems in developing standard data element definitions, and
- the lack of a good vehicle for the dissemination of current information.

It has not been the intent to say that the items mentioned above have been overlooked. These problems have been detected by a number of lower level organizations that have taken a systematic approach to the problem, producing a variety of standards. However, a focal point is needed to coordinate the attack on these problems and facilitate the transfer of programs and information.

In an attempt to disseminate information concerning in-process or recently completed studies, the Army Materiel Command (AMC) distributes the very useful Cost Analysis Monthly Exchange (CAME) published bi-monthly by the Comptroller. The Comptroller has also initiated the development of a data base consisting of study abstracts of all cost-effectiveness studies. After the data base becomes operational, AMC intends to offer a "key word" abstract search capability which should reduce the amount of effort presently required for a cost-effectiveness literature search.[1] Other sources of information on Service-sponsored studies are the Defense Documentation Center, the Defense Logistics Study Information Exchange, the Army Research Office, and the AMC Missile Command (MICOM) RDTE scientific information center.

All of these facilities provide information on studies, but they do not serve as a distribution center for OR programs or techniques, nor do they attempt to evaluate the available operations research approaches to specific classes of problems.

The importance of standard data banks in the integration of the OR community cannot be over-emphasized. A data bank may be defined as a formally designated activity with the primary mission

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of centrally gathering, processing, evaluating, and storing data
to provide selected and summarized information in specified areas.
The implementation of data banks increases systems integration
since, although the data is accessed by many users, it is updated
by only one designated activity. The use of data banks reduces
the problems caused by differences in lack of uniformity in data
element definition, data formats and data file structure.

At present, the major Army commands have established data
banks. In general, these data banks do not appear to be compatible
with each other nor with the Department of the Army data bank.
To combat this incompatibility, Department of the Army created
the Management Information Systems Directorate, and the Army
Materiel Command has begun work on the development of common
data banks under the NAPALM project. A key element of the NAPALM
effort is the development of standard data banks so that many
small existing systems can be integrated. These data banks will
permit the separation of instructions from data in a program, and
reduce one of the major impediments to networking--the trans-
mission of large quantities of data to be manipulated by a program.

Since Congress has expressed interest in the management and
cost of Service-sponsored studies, DoD has issued the following
guidance to the Army:

- Each command (Army Materiel Command, Combat Development
  Command, etc.) will consolidate the study efforts of its
  suborganizations through a central office.
- Each command will disseminate study information among DA
  staff agencies and other major commands to facilitate
  project coordination and the development of a rapid compre-
  hensive response in support of study programs.

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DoD has pointed out that these measures will minimize the possibility of a contractor's performing the same study for different agencies and will promote increased effectiveness in the management of ongoing projects.[2]

The GSA is responsible for maximizing the utility of all government computers. However, since the primary mission of each computer facility is to provide data processing support to its host agency, the data processing support capabilities of the Services are not being utilized as a total integrated resource. Poor ADP support to the customer, duplication of effort, and less than optimum utilization of the total data processing support capability (the overloading of some ADP facilities while others are under-utilized) are the result of this lack of coordination.

As a result, GSA is interested in promoting workload sharing and program exchange between data processing centers. Since the utilization of these techniques should reduce OR study costs and improve turn-around time, the operations research project leader should be interested in effecting workload sharing and program exchange.

WORKLOAD SHARING AND PROGRAM EXCHANGE

Workload sharing may be defined as the transmission (either manually or automatically) of a discrete "job" entity to another ADP installation for execution. Program exchange is the exchange of techniques, subroutines or complete programs which can be used without incurring the expense of additional modification.

Here are some examples of workload sharing between installations. In 1966, the Ground Combat Communications Simulation was run at Fort Huachuca, Arizona, to satisfy a contract let by the systems analysis group at Fort Monmouth, New Jersey. Recently, the U. S. Army Management Systems Support Agency has leased time

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from the Department of the Interior.[3]   Although the extent
of program exchange is difficult to determine, it is evident
that it has been hindered in the past by documentation limitations,
assembly language limitations and the preference of programmers
to develop new programs rather than modify existing programs.

The full benefits of workload sharing and program exchange
have not been realized because of compatibility limitations which
arise due to:

- different hardware,
- different software,
- different operational procedures,
- dissimilar data formats and a variety of definitions of
  data elements,
- geographic separation of installations (under-utilization
  of communication facilities), and
- security.

Compatibility means the ease with which a program running
on one system can be transferred to another, or data generated
in a particular system format can be utilized by another system.
Compatibility may be discussed then in terms of hardware dif-
ferences, software differences, operational procedure differences,
and data format differences. Two other major limiting factors,
geographic separation of installations and security, are inter-
twined. As communication facilities are developed primarily for
transmitting data and as better cryptographic devices are produced,
these factors will become less of a problem.

COMPATIBILITY

In general, data processing installations use incompatible hardware and are configured differently. In the past, computer manufacturers have not attempted to develop systems which were fully compatible with those produced by competitors. Furthermore, only with the advent of third-generation equipment did intra-system compatibility (compatibility among systems produced by the same manufacturer) become important.

It has been suggested that the development of the proper type of software would eliminate compatibility problems. However, one should remember that the objective of each computer manufacturer ᵢt to promote compatibility, but to maximize the sales of his machines. Since processing capability depends upon both hardware and software, it may be assumed that the manufacturer's software is designed to complement his hardware. Thus, even though the objective of each manufacturer is the same, a variety of software packages exists.

Basic software differences exist in the areas of operating systems and languages. Each manufacturer provides a specific operating system to be used with his hardware. These operating systems offer widely differing services in the areas of procedure-oriented language and utility support, hardware support, file management and input/output control, systems services and job control. In general, some compatibility exists among systems of a series developed by a single manufacturer, but there is no compatibility across manufacturing lines. In fact, operating systems and their functions have not been fully defined.

All manufacturers provide assembly languages to be used with their systems. These languages differ extensively with regard to the size and nature of the instruction sets and optional

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features which are provided. Since these languages were designed for system optimization, the lack of compatibility among assembly languages is not surprising.

Procedure-oriented languages (POLs) such as FORTRAN (the de facto scientific programming standard) and COBOL (the standard commercial programming language), were developed to facilitate programming and ease system conversion problems. Since programmers were able to work with a language that was theoretically independent of the machine, the concept of compatibility was promoted. However, only within the past three years has the American Standards Institute sanctioned standard specifications for FORTRAN and COBOL, and today many existing computer systems use compilers which deviate from the USASI standard. These nonstandard features include both restrictions and extensions to the standard specifications so that additional programming capability or greater computer efficiency is provided. In general, these deviations prevent a POL program developed for one system from running on another system without modification.

Data compatibility as such does not currently exist. Existing data banks are machine-dependent, because systems integration was not a main design point at time of installation. The basic data definitions, data formats, and data structures were designed to satisfy internal, not external, requirements. This has necessitated the development of either special data bases or special programs for format translation to satisfy reporting and interface requirements. Standard means of describing data elements and standard approaches to data bank development must be provided so that common information needs may be planned for.

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In summary, the OR user (as well as other users dependent on ADP support) faces long turn-around times in the future. Workload sharing through networking appears to be a possible solution to the OR user, but compatibility problems presently restrict its usefulness. These compatibility problems are due to configuration differences, data format differences, and the use of different versions of the applications language.

FUTURE

In order to better utilize the data processing support available to the government, to improve turn-around time, and to reduce the time required to respond to study directives, some type of networking will probably be implemented in the future. Networking (the step beyond program exchange and workload sharing in the evaluation of a comprehensive, efficient overall ADP support capability) is a technique by which a number of data processing systems, linked by data communications lines, are utilized to provide improved data processing support for the linked installations. In this manner, the extremes of under-utilization and overloading of installations can be avoided. The benefits of networking are:

- improved capability,
- increased availability of resources,
- improved operational efficiency,
- improved ADP backup capability, and
- possibly reduced ADP support costs.

Before networking becomes a reality, however, techniques must be developed which permit interleaving of shared files, facilitate error isolation, and provide both data and program security. These problems are currently being attacked.(4)

In addition, a greater degree of program compatibility is
necessary and further data compatibility is desirable. Program
compatibility may be effected by either using common hardware and
software or by development of a standard interface between computer
systems. In either case, standard programming languages, such as
USASI FORTRAN and USASI COBOL, will play a vital role, as will
the USASCII standard code. These standards will help bind the
various ADP installations into an integrated data processing
resource. With the growth of common data bases, it will become
feasible to separate instructions from data in a program with the
eventual result being the elimination of the expensive transfer
of large amounts of data between data processing installations
and further integration of ADP resources.

To effect the integration of ADP facilities, additional
standards, such as user rules and data conventions, must be
developed. Examples of user rules are:

- general naming conventions for files, items, and solution
  techniques to increase understanding and reduce misinter-
  pretation,
- restrictions on the use of mixtures of languages, espe-
  cially assembly languages, and
- establishment of rules to indicate when various types of
  standards are appropriate.

Data conventions are the fundamental standards which make
data exchange possible.[5] They include:

- standard definitions of data elements,
- standard data names,
- standard definitions of values,
- standard terminology, and
- standard data file structures.

EFFECT ON THE OR COMMUNITY

The OR community should be interested in both program stan-
dardization and data standardization because the OR scope of effort
takes in both developmental and experimental programs with small
data bases and production programs which manipulate large quantities
of data developed by different agencies. Flexibility is gained
if machine-independent languages are utilized in new program
development, because the program can be run at any network link.
Similarly, if data banks are built according to generalized
standardized concepts, only the program will have to be transmitted
since copies of the most utilized data bases can be kept at each
network link; thereby also increasing flexibility.

If operations researchers support and contribute to these
standardization efforts, an integrated, more effective OR community
should result. Duplication of effort should decrease and information
interchange between operations research analysts with similar
problems should increase. Therefore, less time should be wasted
on unproductive efforts and more time can be devoted to original
research.

Report generation should become easier for the operations
research analyst because the need for building special programs
to translate formats or modify data bases to satisfy reporting
requirements should diminish. At the same time management will
benefit in that:

- The development of long-range plans will be easier because
  summarized management information will be available on
  current OR projects according to category.
- Better guidance should result because a common approach to
  planning, review, and analysis will be feasible.

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CONCLUSIONS

The OR user may object that, although standardization and centralization may be useful, it is not his function to develop standards. This may be true. However, as networking concepts are increasingly utilized to improve the quality of ADP support, additional standardization will be necessary. Thus, the OR community will greatly benefit by contributing to the development of standards, rather than being forced to accept unrealistic or useless standards. It is hoped that the OR community will recognize the need for further analysis of both program and data standardization needs and appoint an ad hoc group to determine the desirability of:

- Enforcement of a standard documentation technique,
- Development of a library of operations research programs,
- Development of a library of standard approaches to specific types of OR problems,
- Development of standardized and generalized program design techniques to prevent individualized short-run solutions to new types of OR problems,
- Joint program development by the major Army commands or joint program development with the Navy, Air Force, and NASA on similar types of problems,
- Definition of specific types of OR problems as candidates for standardization,
- Development of benchmark problems for the comparison of alternative approaches to the solution of the various types of OR problems, and
- Development of a monthly and newsletter or publication dedicated to the dissemination of information on current operations research projects.

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Common mathematical and statistical algorithms and standard
approaches to the solution of specific problem types should be
effected. The capability of breaking large programs into segments
to be run at separate facilities and the growth of central data
banks will become a reality.

As an example of some of the benefits to the OR community
from increased standardization, consider the present situation
which exists in deployment planning in DoD. Deployment planning
is the allocation of transportation and logistics resources so
that operations will be optimized. Presently, the Army, Navy,
Air Force, and Marine Corps have developed different resource
allocation models for deployment planning, and deployment monitoring.
Since different techniques, assumptions, constraints and data
formats are utilized by the Services, it is extremely difficult
for JCS to integrate the results of the Service programs into a
comprehensive DoD program. Since the Service programs and data
formats are different, they do not provide a backup capability
for each other and the development of integrated data banks has
been restricted. It is hard to justify such conditions and the
resultant loss of flexibility.

Similarly, the trajectory estimation requirements of the Armed
Forces and NASA are quite similar. The Air Force Eastern Test
Range, TRW, and Autonetics (TRW and Autonetics provide system
engineering support for the Minuteman III project) have developed
trajectory estimation programs which are utilized by the Air Force;
Lockheed has solved this problem for the Poseidon missile tests
and Lockheed developed another program for NASA's Saturn project.
All solutions produce similar results. This problem area appears
to be one in which great savings would accrue if standardized and
generalized system design and documentation techniques were utilized.

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